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STUDY ON STRENGTH CHARACTERISTIC OF CONCRETE MASONRY UNITS USING RECYCLED CONCRETE AGGREGATES

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ABSTRACT

Recycled aggregates are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris or any type of concrete waste. In the present work it is decided to determine the strength characteristics of concrete masonry units using recycled aggregates as an alternative material to natural coarse aggregate and fine aggregate. The investigation has been carried out for concrete blocks by compressive strength test, water absorption, block density etc. A total of five batches of concrete mixes consist of every 25% increment of recycled aggregate replacement from 0% to 100%. The results shows that all of concrete waste mixtures can be used to produce concrete blocks but 75% replacement shows a very good strength and cost can also be reduced to 35-40% of original cost.

Key words: Recycled Aggregates; Specifications; Sustainable Development Construction and Demolition Debris, Concrete Blocks.

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1. INTRODUCTION

Recycling is the act of processing the used material for use in creating new product. The Usage of natural aggregate is getting more and more intense with the advanced development in infrastructure area. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. Recycled aggregate are comprised of crushed, graded inorganic particles processed from the materials that have been used in the constructions and demolition debris. These materials are generally from buildings, roads, bridges, etc.

1.1. Necessity for the re-use of recycled aggregates

- Many old buildings and other structures have overcome their limit of use and need to be demolished;
- Structures even adequate to use are under demolition because there are new requirements and necessities.
- Creation of building wastes which result from natural destructive phenomena (earthquakes, storms etc)

2. METHODOLOGY

2.1. Introduction

This chapter deals with the materials collected from different sources which were used in the present study. Further the testing techniques used are also reported.

2.1.1. Cement

Ordinary Portland cement of 53 grade confirming to IS 8112-1989. Various physical properties such as specific gravity, fineness, initial and final setting time test were performed as per IS 269-1976 and IS 4031-1988.

2.1.2. Fine Aggregate

Commercially available river sand is used in the present study. Grain size distribution was carried out as per as IS 383.

2.1.3 Recycled coarse aggregate:

Generated concrete waste at Ultra-Tech RMC plant is used in the present study.

2.2. Characterization of Natural aggregate and Recycled aggregate

Table 1 Property of Natural aggregate and Recycled aggregate

Sl No	Particulars	Natural Aggregate	Recycled Aggregate
1	Source	Locally Available	RMC Plant
2	Max. Aggregate Size	20mm	20mm
3	Specific Gravity	2.8446	2.74
4	Fineness Modulus	7.086	7.476
5	Density	1805.62 Kg/m³	1660.44 Kg/m³
6	Impact Value	8	12.92

2.3. Manufacturing process

The production of concrete blocks consists of four basic processes: mixing, molding, curing and drying. The following steps are commonly used to manufacture concrete blocks.

- As a production run starts, the required amounts of stone dust, gravel, (Natural aggregates and recycled aggregates) and cement are transferred to the stationary mixer manual or mechanically.
- The dry materials in the stationary mixer where they are blended together for several minutes.
- After the dry materials are blended, a small amount of water is added to the mixer. If the plant is located in a climate subject to temperature extremes, the water may first pass through a heater or chiller to regulate its temperature. The concrete is then mixed for six to eight minutes.
- The consistency of the mix should be such that it may cohere when compressed in the hand without free water being visible.

Figure 1 Molding of aggregates mix

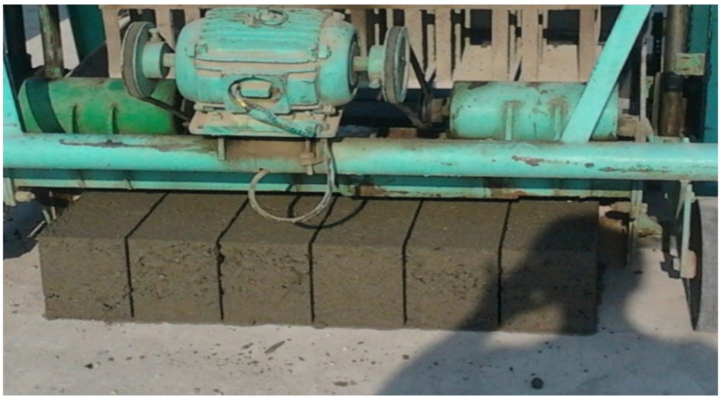

Figure 2 Fresh concrete masonry unit

3. EXPERIMENTAL PROGRAM

The following tests has been be conducted on the concrete block

- Compressive Strength.
- Water Absorption.
- Block density.

3.1. Determination of compressive strength

The compressive strength of a concrete masonry unit shall be taken as the maximum load in Newton's divided by the gross cross-sectional area of the unit in square millimeters. The gross area of a unit is the total area of a section perpendicular to the direction of the load, including areas within cells and within re-entrant spaces unless these spaces are to be occupied in the masonry by portions of adjacent masonry. The results to be determined to the

nearest0.1 N/mm^2. Each unit shall be tested separately an average of 2 units can be taken as the mean average compressive strength of the concrete masonry unit. The compression strength of the block is determined at 7th day and 21st day after curing. The below tabular column represents the compressive strength of all the replacements from 100%, 75%, 50%, 25% and 0% replacement of aggregates.

$$\textbf{Compression strength of block} = \frac{\textbf{load}}{\textbf{gross cross-sectional area}}$$

Figure 3 Observation for compressive Test

Table 2 Compressive strength of Concrete Masonry Block at 7 days

% Replacement	100%		75%		50%		25%		0%	
Sample No.	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Load	209	216	318	319	268	229	176	182	163	167
Compressive strength(Mpa)	2.612	2.7	3.974	4	3.35	2.862	2.2	2.28	2.037	2.087
Average compressive strength(Mpa)	2.656		4.0		3.106		2.24		2.062	

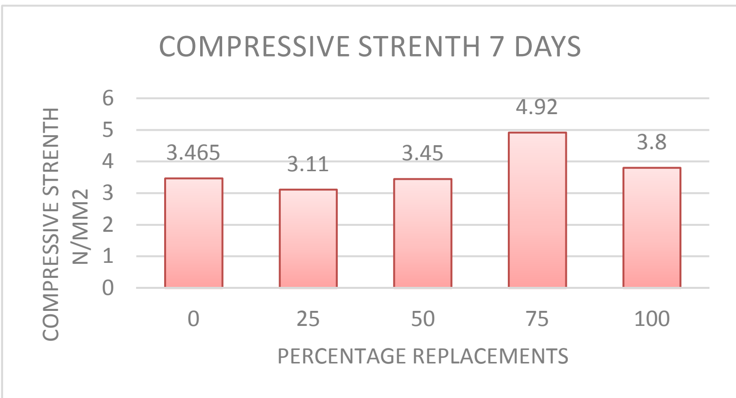

Figure 4 Graph showing compressive strength at 7th day

Observation: compressive strength of concrete masonry block using recycled aggregate with 75% of replacement over a natural aggregate shows better result than the concrete block using natural aggregate at the age of 7 days.

Table 2 Compressive strength of Concrete Masonry Block at 21 days

% Replacement	100%		75%		50%		25%		0%	
Sample No.	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Load	314	294	390	397	270	281	242	256	272	283
Compressive strength(Mpa)	3.92	3.675	4.875	4.962	3.375	3.512	3.025	3.2	3.4	3.53
Average compressive strength(Mpa)	3.8		4.92		3.45		3.11		3.465	

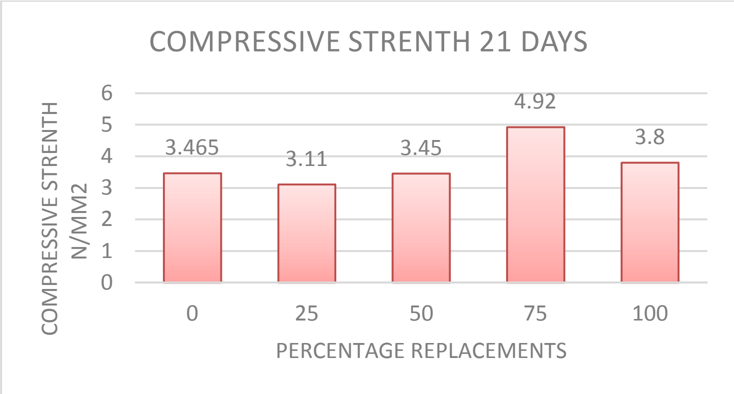

Figure 5 Graph showing compressive strength at 21st day

Observation: compressive strength of concrete masonry block using recycled aggregate with 75% of replacement over a natural aggregate shows better result than the concrete block using natural aggregate at the age of 21 days.

3.3. Determination of water absorption

The test specimens shall be completely immersed in water at room temperature for 24 hours. The specimens shall then be weighed, while suspended by a metal wire and completely submerged in water. They shall be removed from the water and allowed to drain for one minute by placing them on a 10 mm or coarser wire mesh, visible surface water being removed with a damp cloth, and immediately weighed.. The average of two units gives the % of water absorption.

$$\textbf{Water Absorption} = \frac{\mathbf{A-B}}{\mathbf{B}} \mathbf{\ x\ 100}$$

Where, A= wet mass of block B= dry mass of the block

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Table 3 water absorption of Concrete Masonry Block

% Replacement	100%		75%		50%		25%		0%	
Sample No.	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Wet wt =A(kg)	24.54	24.30	25.53	25.63	26.25	24.11	24.31	24.30	24.03	23.70
Dry wt = B(kg)	23.74	23.64	24.91	24.76	25.47	23.06	23.37	23.36	23.03	22.66
Water Absorption (%)	3.365	2.817	2.472	3.501	3.077	4.525	4.022	4.0	4.32	4.56
Average Water Absorption (%)	3.091%		2.986		3.801		4.011		4.443	

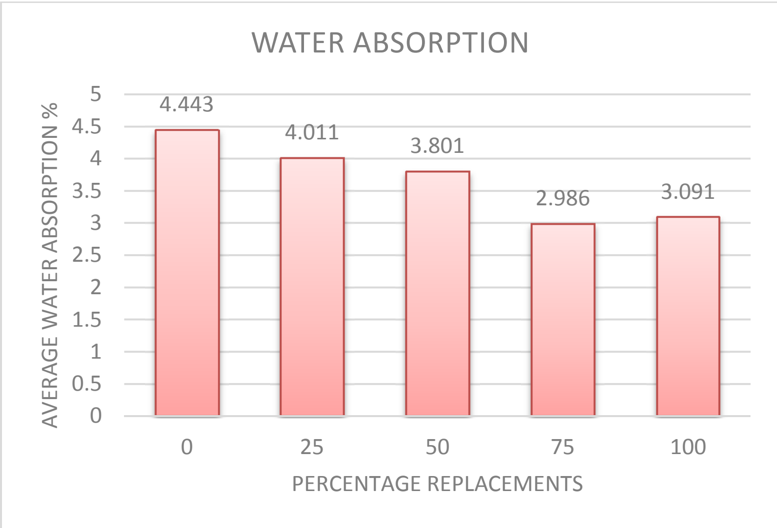

Figure 6 Graph showing average water absorption in %

Observation: water absorption of concrete masonry block using recycled aggregate with 75% of replacement over a natural aggregate shows less water absorption result than the concrete block using natural aggregate.

3.3. Determination of Block Density

The density of the block calculated as follow

$$\text{Density} = \frac{\textbf{Mass of block in kg}}{\textbf{volume of specimen in cm}^3} \text{ x } \mathbf{10^6 kg/m^3}$$

Table 4 Density of Concrete Masonry Block

% Replacement	100%		75%		50%		25%		0%	
Sample No.	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Mass (kg)	23.56	23.079	24.2	24.74	24.4	24.35	23.6	23.31	23.5	23.63
Volume(m^3)	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
Density (kg/m^3)	1963	1923	2022	2061.6	2040	2029	1974	1943	1959	1969
Avg Density (kg/m^3)	1943		2041		2034		1958		1965	

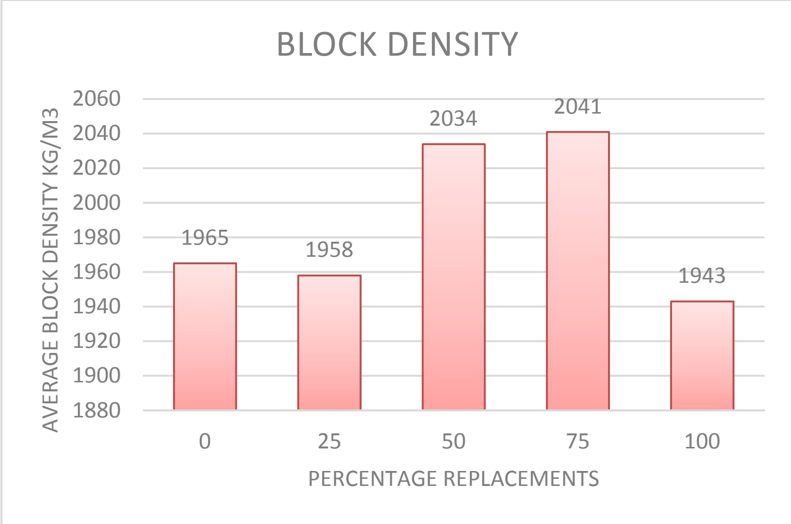

Figure 7 Graph showing average block density

Observation: Density of concrete masonry block using recycled aggregate with 75% of replacement over a natural aggregate shows better result than the concrete block using natural.

4. RATE ANALYSIS FOR CONCRETE MASONRY UNIT

The following procedure has been adopted for cost analysis.

4.1. Analysis of rate for 100% replacement blocks

The proportion used to manufacture 100% recycled aggregate block is **1:4:4** (cement, recycled sand, recycled aggregates).

For $1m^3$of cement concrete, the quantity of cement required is $0.115m^3$.

Total demolition waste obtained from the source is 8 bags (i,e in 50 kgs cement bag).

Unit weight or density of cement = 1440 kg/cum

If the bag is completely filled, then = $\frac{50}{1440}$ = 0.034 cum.

But the bag is approximately 75% filled, hence the quantity of waste obtained in each bag

= 0.75 X 0.034 cum

=0.026 cum/bag.

The total quantity of waste obtained is = 0.026 cum X 8 bags

= 0.208 cum.

The volume of each block is 0.15mX0.20mX0.40m = 0.012cum.

The volume of 6 blocks (6 blocks were casted at a time) = 0.072cum.

For 1cum of cement concrete we require 0.115 cum of cement, but for 0.072 cum of concrete we require 0.00828 cum of cement.

Total volume of aggregates in 6 blocks = $0.072m^3$- $0.00828m^3$(deducting volume of cement)

= $0.06372m^3$of aggregates.

Since we have used equal proportion (i.e. 1:**4:4**) of fine and coarse aggregates, the volume of each aggregates is = $\frac{0.06372\ \text{cum}}{2}$ = 0.03186 m^3.

Assuming;

Natural sand (stone dust) = 20 Rs per CFT

Recycled sand = 15 Rs per CFT

Natural coarse aggregates = 15 Rs per CFT

Recycled coarse aggregates = 10 Rs per CFT

Ultra-Tech cement bag = 350 Rs per bag.

Then the quantity of materials required for molding of 6 blocks is,

Cement = 0.00828m^3X 30 = 0.25 bags = 3.75 kg = 26.25 Rs

Recycled sand = 0.03186m^3= 1.126 CFT = 1.126 X 15 = 17 Rs

Recycled aggregates = 0.03186m^3= 1.126 CFT = 1.126 X 10 = 11.26 Rs

The total cost of all the raw materials required for molding 6 blocks = **54.51** Rs

Additional Charges:

Labour charges = 12 Rs

Electricity charges = 3 Rs

Water charges = 6 Rs

Machinery and tools = 2 Rs

For land = 6 Rs

Lum-sum = 6 Rs

Total additional charges = **35** Rs

Total cost for manufacture of 6 blocks = **54.51 + 35** Rs.

= **89.51** Rs.

Cost for each block = **14.91 ≈ 15** Rs.

Cost of each block available in market = **27** Rs per block.

Saving on each recycled aggregate block = **12** Rs per block.

4.2. Analysis of rate for 75% replacement block

(The analysis is same as the above except material calculation)

Then the quantity of materials required for molding of 6 blocks of 75% replacement is,

Cement = 0.00828m^3X 30 = 0.25 bags = 3.75 kg = 26.25 Rs

Natural sand = 0.007965m^3= 0.281 CFT = 0.281 X 20 = 5.62 Rs

Recycled sand = 0.023895m^3= 0.85 CFT = 0.85 X 15 = 12.75 Rs

Natural aggregates = 0.007965m^3= 0.281 CFT = 0.281 X 15 = 4.215 Rs

Recycled aggregates = 0.023895m^3= 0.85 CFT = 0.85 X 10 = 8.5 Rs

The total cost of all the raw materials required for molding 6 blocks = **57.335** Rs

Additional charges:

Labour charges = 12 Rs

Electricity charges = 3 Rs

Water charges = 6 Rs

Machinery and tools = 2 Rs

For land = 6 Rs

Lum-sum = 6 Rs

Total additional charges = **35** Rs

Total cost for manufacture of 6 blocks = **57.335 + 35** Rs. = **92.335** Rs.

Cost for each block = **15.38 ≈ 16**Rs.

Cost of each block available in market = **27** Rs per block.

Saving on each recycled aggregate block = **11** Rs per block.

5. CONCLUSION

Research on the usage of waste construction materials is very important due to the materials waste is gradually increasing with the increased of population and increasing of urban development. The reasons that many investigations and analysis had been made on recycled aggregate are because recycled aggregate is easy to obtain and the cost is cheaper than virgin aggregate. Virgin aggregate need to mine but recycled aggregate can ignore this process.

This research project is to determine the strength characteristics of recycled aggregate concrete masonry units (blocks) for structural buildings. Furthermore, with the cheaper price of recycled aggregate compared to natural aggregate, the builders can carryout the construction task with lesser material costs.

The results show that all of concrete waste mixtures can be used to produce both hollow non-load and load-bearing concrete blocks. Economically, the 75% and 100% concrete waste mixtures can reduce the cost at 35-40% per block. Using the100% concrete waste mixture to make a concrete block can reduce the maximum cost at 35% per block, which is more lesser than the regular price of each solid block in the market.

In summary, the result indicated that the production of the concrete blocks mixed with 75% concrete waste use as the aggregate in concrete blocks, could be a profitable disposal alternative in the future and would be of the highest value possible for the future.

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